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TYPE II PROGRESS REPORT - NUMBER 3

Period: July 1, 1973 to December 31, 1973

INVENTORY OF FOREST AND RANGELAND AND DETECTION OF FOREST STRESS

GSFC Identification Number AG-014, MMC-226
Contract Number S-70251-AG

Report date - January 20, 1974

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TECHNICAL REPORT STANDARD TITLE PAGE

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15. Supplementary Notes

16. Abstract Visual interpretation of ERTS imagery on range and forest sites in Colorado shows that no discriminations can be made to the habitat level. This is the ecosystem class where management decisions are made. Discrimination to broader classes, Series and Region, can be made only when strong spectral differences exist--such as aspen versus all conifers or large wet meadows in dry grassland types.

Forest stress caused by cold temperatures killing large stands of Eucalyptus trees in the Berkeley-Oakland Hills of California could be identified by combining two dates of ERTS images--one date in January (ID 1183-18175) before foliage discoloration, the second date in April (ID 1273-18175) after the foliage turned yellow-red but before the native grasses turned yellow.

Disturbances to the forest environment that cause reductions in forest area can be detected about 80 percent of the time on ERTS color composites when conditions are optimum. This was done by comparing an April ERTS color composite (ID 1264-15445) with 1:63,360 index sheets of aerial photography. Factors which affected accuracy were (1) quality of imagery,

(continued on next page)

17. Key Words (Selected by Author(s))	18. Distribution Statement
Forest inventory, forest stress, rangeland inventory, photogrammetry, automatic data processing and signature analysis	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
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Figure 2. Technical Report Standard Title Page

16. Abstract (Continued)

(2) season--winter, early spring and summer were best, (3) size of disturbed area, (4) number of years since disturbance--older and smaller ones were more difficult to find, and (5) type of cutting treatment--clear cuts were easier than partial cuts.

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Atlanta Test Site (Forest Inventory) 226B

Coinvestigator: Robert C. Aldrich

GSFC Identification Number AG-014

Principal Investigator: Robert C. Heller

STATEMENT OF PROBLEMS:

1. Some color composites for images required in our analysis have not been received.

Scene Number	Date Ordered
1265-15503	May 25, 1973
1299-15385	July 19, 1973
1336-15441	September 25, 1973

2. A film holder with vacuum back and a vacuum pump was obtained to improve registration of color composites made on the I^2S additive color viewer. Color composites with image enhancements that discriminate between major land-use classes are being made to the scale of 1:1,000,000 overlays. Progress has been slow because of other required photographic activities and annual leave during the holiday season.

3. Our mathematician-programmer resigned unexpectedly in December leaving us in a rather poor position to continue our computer classification research. A replacement has been hired; however, it will take a month or two to regain our former capabilities.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

Preparations and Equipment Developments:

1. A new technique was devised that will combine, enhance, and enlarge bulk 70 mm ERTS images to the scale of 1:1,000,000 map overlays. In this technique an I^2S additive color viewer is used much like a photographic enlarger. Two or three kinds of bulk 70 mm black-and-white bulk MSS data are combined and scaled on the viewer screen. Once the image is scaled, the screen is removed and replaced by a special 8 X 10-inch film holder with vacuum back--a vacuum pump is turned on during exposure to insure that the film is flat for best registration

of all images. The illumination levels of each channel, and all channels combined, are measured with a Forest Service designed-and-built photometer. These data are used to determine exposure time and to standardize exposures on Kodak internegative color film. A commerical timer with increments of one-tenth second is used to time the correct exposure.

2. Transparent film overlays for the test site were made using film copies of the original USGS base of 1:250,000 map sheets for Atlanta and Rome. Systematic errors in point locations that were caused by map dimensional instability have been removed, and we now have better correlation between ERTS data positions and the map control.

3. A hierarchy was developed for land classification that can be used with ERTS and higher resolution remote sensing data that can also be related to Forest Survey ground classifications (Table 1). This scheme is flexible and makes ERTS and other levels of remote sensing data more compatible with one another and with the ongoing nationwide Forest Survey.

Aircraft and Ground Support:

1. There were no aircraft support or ground support missions during the six-month reporting period.

Film Data Analysis:

1. Using the land classification hierarchy in Table 1, eight Level II classes identified and described on Goddard-produced simulated color infrared composites for ERTS scenes 1084-15440 (October 15, 1972) and 1264-15445 (April 14, 1973). Munsell color standards were used for the color descriptions.[1]

Conifer

Density of the conifer stands and the number of hardwoods mixed in the stand influence the Munsell Standard color value and chroma. Dense stands are darker with less chroma. In the fall before advanced hardwood coloration and leaf fall have occurred, conifer stands appear dark purplish red. The separation between conifer and hardwood is less distinct in the fall than in the winter or early spring. In stands where hardwoods and conifers are mixed, the hardwood color predominates, and the stand is usually classified as hardwood. In the spring before hardwoods are foliated, conifer appears moderate to dark purplish red.

[1]The ISCC-NBS Method of Designating Color and a Dictionary of Color Names. U. S. Department of Commerce, NBS, Circular 553. Nov. 1, 1955.

Hardwood

Appear moderate grayish purplish red in the fall and a pale purple to moderate purplish red in the spring. In the fall, upland hardwoods cannot be distinguished from bottomland hardwoods. In the spring before foliation, upland hardwoods appear pale purple to light grayish purplish red. Bottomland hardwoods are generally a moderate purplish red.

Grassland

A deep pink in both fall and spring. Is sometimes mistaken for immature cropland in spring.

Cropland

Mature crops in the fall appear bluish gray to grayish blue. In the spring immature crops appear a deep pink and may be called grassland because of the similarity.

Bare Soil

In fall and spring appears cream colored. There is no distinction between plowed agricultural fields and sites prepared for new commericial developments. Generally in the spring most areas of bare soil are newly plowed fields prior to, or immediately after, planting.

Wild Vegetation

In the fall this class ranges from the grayish purple of idle land, to grayish purplish red of abandoned land, to the deep pink of wild Kudzu vine. Marsh and older swamps are a moderate purple due to the wet background. In the spring, idle land becomes a light grayish red to dark pink due to the influx of new IR reflectant vegetation. Abandoned-transitional land (reverting to forest), on the other hand, is a grayish purplish red and marsh and older swamps are a grayish violet. The deciduous Kudzu vine, a purplish gray in the spring, easily separates itself from all other vegetation when fall and spring images are viewed together.

Urban

A light, light blue in the fall and very pale blue in the spring. Unfortunately, because of the low resolution of ERTS data, secondary roads, minor roads, and most utility lines are not resolved.

Water

Dark greenish blue in the fall and light greenish blue in the spring. Farm ponds of less that one acre can be seen on ERTS images if sufficient contrast exists with the surrounding background.

2. A preliminary photo interpretation study was made to test the feasibility of clarifying land based on the center of 500-meter samples rather than the NW corner as specified in the original proposal. Ninety-two training samples that fell in the quadrauple 84°00'-84°30'W longitude and 33°00'-33°30'N latitude were examined and classified into the eight Level II classes in our land classification hierarchy described in Table I.

Goddard-produced color composites for scenes 1084-15440 and 1264-15445 were interpreted individually using a stereomicroscope with 7X magnification. A second interpretation was made one week later interpreting the two scenes simultaneously with an Old Delft Scanning Stereoscope.

Results of interpretation showed that only 37 of 92 points (40 percent) were correctly classified on scene 1084-15440. On scene 1264-15445 only 31 percent were correct. When the two scenes were combined and interpreted together the results were much better with 59 points or 64 percent correctly classified. These results are far below the accuracy required in land-use classification. However, they do show enough promise to make a more complete test using improved combined color images, made in our own photographic laboratory, for three seasons--fall, early spring, and early summer. This will be done as soon as color composites of maxiumum quality are available.

3. The U. S. Department of Agriculture aerial photo index sheets of 1:20,000 panchromatic photography, taken for Carroll County, Georgia, in 1966, were examined simultaneously with Goddard color composite of ERTS scene 1264-15445 (April 14, 1973). A Zoom Transfer Scope (ZTS) with special modifications made it possible to examine the 1:1,000,000 scale ERTS scene and the 1:63,360 photo index sheet at the same time. Using this system, changes in land use from forest to nonforest, changes from nonforest to forest, and all other suspected forest disturbances were noted and circled directly on the photo index sheets. These suspected changes and disturbances were then checked on June 1972 high-altitude color infrared (CIR) photography. Information was recorded in three categories: (1) changes of disturbances correctly identified, (2) changes or disturbances incorrectly identified (commission errors) and (3) changes or disturbances not identified (ommision errors). Changes not identified on ERTS were noted on the index sheets and reexamined on the ERTS color composite. A record was made of the changes or disturbances that were considered detectable as well as those that could not be detected. For each disturbance the following was recorded.

a. The type of disturbance
b. The land-use trend indicated by the change
c. The area covered by the disturbance in one of 6 classes

   1. less than 5 acres
   2. 6-25 acres
   3. 26-50 acres
   4. 51-100 acres
   5. 101-500 acres
   6. over 500 acres

d. Disturbances detected on ititial ERTS examination
e. Disturbances detected on 1:120,000 CIR film
f. Disturbances detected on ERTS on second examination.

The results of this study showed that there were 209 forest disturbances detected on the 1:120,000 CIR photographs. Of these, 85, or 40 percent, were detected originally on the ERTS color composite by cursory examination.

One hundred and eight-two, or 86 percent, could be detected on ERTS by a more deliberate, careful second examination.

4. To verify the above results, an independent interpreter was asked to examine 245 locations circled on 1:63,360 aerial photo index sheets for Carroll County. In addition to the 209 photo-verified disturbances, 36 additional locations were circled where no known disturbances existed. Following a short orientation period, the interpreter was instructed that he was to examine 245 locations where there might be a forest disturbance. He was to indicate the type of disturbance, the appropriate size class, and the land-use trend if possible. The results of this examination are given in Table 2.

These results indicate that approximately 80 percent of disturbances larger than one acre in size can be detected on ERTS color composites. In this study there were 23 verified disturbances circled where a disturbance was detected but put in the wrong class. These were called misclassification errors. Another type of error is caused when a disturbance is detected where there is none--there were 21 of these errors. These errors are called commission errors. Errors of both types could be reduced and kept under control using aerial photographs in place of photo index sheets. Improved training and more experience in using this new type of remote sensing data will also improve interpretation.

5. A random sample of 21 disturbances (10 percent) was selected and ground checked during the period of January 5 through January 10, 1974. These samples were distributed by disturbance class as follows:

Harvesting................	7
Natural regeneration.......	6
Artificial regeneration....	2
Other (including Urban)....	6
	21

We did not field check the "cleared" category because we felt the CIR photo verification was probably correct.

Of the 21 points sampled only 2 were found not disturbed on the ground.

Fifteen, or 71 percent, were found classified correctly. The remaining four points, though disturbed, were interpreted in different categories. The difference was primarily a matter of definition, i.e., a harvested area with natural regeneration or natural generation on a harvested area. The main point is that a disturbance occurred and was detected. By including these four points as identified disturbances, 90 percent of the ground samples discovered on ERTS images were found disturbed in some way. This means foresters could rely on the photo detection of forest disturbances 90 percent of the time.

Digital Tape Analysis:

1. Work continued on unsupervised clustering procedures and procedures aimed at stratifying the data with ground types rather than spectral types. Ground truth maps were completed for two 10,000-acre study areas and reproduced at a 1:20,000 scale. These maps were prepared from 1:120,000 CIR photography taken October 2, 1972. The scale of the maps is the same (1:20,000) as computer maps produced by an EAI 430 plotter and will be used in making the final evaluation of computer classification accuracy for ERTS scene 1084-15440 (October 15, 1972).

2. Several unsupervised map clusters have been made based upon frequency histograms for each spectral channel. In this technique the frequency histogram for radiance data in each individual spectral channel is divided into a number of intervals to produce spectral clusters. To date, the best cluster appears to be made using all four channels with the spectral frequency histograms divided into two intervals--above and below the median value.

3. The first computer land-use map was produced with nine classes--five forest and four nonforest. Although there was good correlation between the forest and nonforest area classified on the computer map and the same broad classes on the ground truth map, five forest types were too many for the spectral resolution of ERTS data. For this reason a

second computer map was made using the following six forest and nonforest classes:

1. - Pine
2. - Hardwood (deciduous)
3. - Grassland
4. - Cropland Bare Soil Combined
5. - Water

Cropland and bare soil were combined on this map because there were too few samples of these two classes to use as training sets. The Urban category, which is one of the eight classes that we have found detectable on ERTS, was eliminated for the same reason--too few samples for training the computer. For these reasons the final computer classified map was made up of only six classes. When they were compared with the ground truth it was easy to see that the best correlations exist between pine, hardwoood, grassland, and water. Cropland, bare soil, and wild vegetation apparently do not have strong enough signatures and are easily confused with one another. Since the Forest Survey is primarily interested in forest land acreage, the accuracy of the separation between forest and all nonforest land is important and will be checked more thoroughly.

WORK PLANNED FOR NEXT REPORTING PERIOD:

Preparations and Equipment Development:

1. No further development is planned or needed.

Aircraft and Ground Support :

1. No aircraft or ground support missions are planned.

Film Data Analysis (Photo Interpretation):

1. Photographic keys will be developed to illustrate land-use and forest classifications by season.

2. A land-use classification test will be conducted using a multi-seasonal approach to classification. Thirty randomly selected sample points in each of eight forest and nonforest classes will be examined and classified by three interpreters. In the first phase of the test, interpreters will use a combination of ERTS color composites for scenes 1084-15440 (October 15, 1972) and 1264-15445 (April 13, 1973). In a second phase, ERTS color composites for scenes 1264-15445 and 1336-15441 (June 24, 1973) will be interpreted.

3. We will continue to monitor Forest Survey plots on both high-altitude photography and ERTS imagery to determine the feasibility of using ERTS on permanent plots to measure changes in forest area and to detect disturbances.

Digital Tape Analysis:

1. We hope to make a numerical assessment of mapping accuracy for four different computer classification methods: (1) no clustering-typing of individual pixels according to means of land-use prototypes, (2) clustering using "slicing" of the four-dimensional data distribution, (3) clustering using distances between adjacent pixels, and (4) a quick clustering method based upon correlation of radiance values.

2. We will extend our best classification procedures to ERTS data for scene 1264-15445 (April 1973) and scene 1336-15441 (June 1973)

SIGNIFICANT RESULTS:

1.Disturbances in a forest environment that cause reductions in forest area, timber volume, and timber growth can be detected on ERTS combined color composites. However, detection depends on comparing a conventional aerial photograph taken at some base year with an ERTS image taken in some subsequent year. In a test made on the Atlanta site, 1:63,360 scale aerial photo index sheets made in 1966 were compared with ERTS image 1264-15445 (April 1973). Five factors were found important to detection reliability: (1) the quality of the imagery, (2) the season of the imagery, (3) the size of the disturbed area, (4) the number of years since the disturbance, and (5) the type of cutting treatment. Of 209 disturbances verified on aerial photography, 165 (or approximately 80 percent) were detected on the ERTS image by one independent interpreter. Improved training and additional experience in using this low-resolution imagery should improve detection. Of the two seasons of data studies (fall and early spring), early spring is the best for detecting land-use changes. Generally speaking, winter, early spring, and early summer are the best times of year for detecting forest disturbances.

PUBLICATIONS:

1. Myhre, Richard J. 1973. Producing high-quality negatives from ERTS black-and-white transparencies. U.S.D.A. Forest Service Research Note PSW-287, 6 p., illus.

RECOMMENDATIONS FOR CHANGES: None

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: 10 Submitted

DATA REQUEST FORM CHANGES: None

TABLE 2. DISTRIBUTION OF FOREST DISTURBANCES BY TYPE AND AREA CLASSES AND THE NUMBER AND PERCENTAGE OF ALL DISTURBANCES DETECTED BY ONE INDEPENDENT INTERPRETER

DISTURBANCE	AREA CLASS (ACRES)						
	Less than 5	5-25	26-50	51-100	101-500	Over 500	Total
	Number of Disturbances						
Harvested Forest Land	4	11	8	4	10	8	45
Land Clearing							
Forest to Agriculture	51	35	5	7	2	0	100
Forest to Urban	7	11	3	0	0	2	23
Forest to Water	12	5	1	0	0	0	18
Regeneration to Forest	1	5	0	1	0	1	8
Other	1	10	1	0	3	0	15
Total	76	77	18	12	15	11	209
Number detectable	58	65	14	9	10	9	165
Percent detectable	76	84	77	75	66	81	79

TABLE I. A land classification hierarchy for remote sensing and ground information sources compatible with current nationwide Forest Survey objectives.

Remote Sensing Information			Ground Information
Level I	Level II	Level III	Level IV
		Land Classification	
Forest Land	Conifer	Pine	Forest Type by Dominant Pinus sp.
		Pine-Hardwood	
	Deciduous Hardwood	Upland Hardwood	Forest Type by Dominant Hardwood sp.
		Bottomland Hardwood	
	Grassland	Undisturbed Grass	
		Disturbed Grass	Improved & Unimproved Pasture & Range
		Dead Grass (Annual)	
		New Improved Grass	
	Cropland	Immature Grain	
		Immature Row Crop	
		Mature Crop	Cropland
		Harvested Crop	
		Orchard	
		Farm Steads	Other Farmland
Non Forest Land	Bare Soil	Plowed Fields	
		Errosion	Cropland
		Urban	
		Rock outcrop	Urban & Other
	Wild Vegetation	Idle Land	
		Abandoned Land	
		Transitional	Idle Farmland
		Kudzu	
		Marshland	Marsh
		Alder Swamp	Alder Swamp
	Urban	Transportation & Utilities	
		Home Developments	
		Commercial Developments	Urban & Other
		Recreation	
	Water	Clear Lakes & Ponds	
		Torbid Lakes & Ponds	Water[1]
		Rivers & Streams	

Information Source[2]			
ERTS - 1	ERTS - 1 Other Satellite Photography	Other Satellite Photography High Altitude Photography	Forest Survey Field Procedure[3]

[1] Includes both Bureau of Census and other water by definition.

[2] The minimum sensor resolution acceptable to obtain the level of information required.

[3] Forest Survey Manual for the Southeast, Parts I through V., U. S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, NC . 1968.

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Manitou Test Site (Rangeland Inventory) 226C

Coinvestigator: Richard S. Driscoll

GSFC Identification Number AG-014

Principal Investigator: Robert C. Heller

STATEMENT OF PROBLEMS:

1. Retrospectively ordered bulk color composites of the Manitou test site (226C) per se, for which we have a significant portion of our ground truth, have not all been received. This includes five frames of 1973 data that include the total Manitou test site in each frame and which should show any temporal changes that might assist in interpretation for plant community classes. All but two of seven bulk color composites of our alternate Kremmling site have been received.

2. The Bausch and Lomb ZTS ordered in June 1973 has not yet been received. Delivery has been promised by February 1, 1974, at which time it will be put to good use for our interpretation procedures.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Mr. Heller presented the results of our portion of the experiment, along with the forest inventory and forest stress portions, at the ERTS Investigators' Panel Review meeting. We would like to determine at what level in the plant community classification hierarchy (ECOCLASS) ERTS-1 imagery can be successfully used. This system, which is analogous to most classification systems, is in current use by natural resource managers and is also outlined in our Type I Progress Report--Number 6.

Category	Definition
V - Formation:	The most general class of vegetation characterized by general appearance: i.e., grassland, coniferous forest, deciduous forest, etc.

Category (Cont)	Definition (Cont)
IV - Region:	Groups of community systems with similar appearance and climatic controls: i.e., montane grasslands, temperate mesophytic (medium moisture requirements) coniferous forests, montane grassland, alpine grasslands.
III - Series:	A group of vegetation systems having common dominate climax species: i.e., ponderosa pine forests, lodgepole pine forests, fescue grasslands, wheatgrass grasslands.
II - Habitat Type:	The unit with relatively pure internal biotic and abiotic structure: i.e., ponderosa pine-Arizona fescue, thurber fescue-aspen fleabane. These are the elemental units of the plant community classification scheme upon which management is based. Frequently related to "climax" situations or situations in a high successional level "held" in a relatively stable state by proper management.
I - Community Type:	Systems that appear relatively stable under management and may be frequently equivalent to the habitat type. Usually the biotic components are dissimilar but abiotic components analogous to habitat type.

2. ERTS image I.D. Number 1028-17135 is the only color composite we have that includes the total 226C test site. On this image we were able to classify our targets by microscopic evaluation to the following levels in the ECOCLASS System:

a. Interpretations to levels IV and V, Region and Formation are clearly definitive using only ERTS data. Such broad classes can be separated with coarse resolution sensors.

b. Interpretations to level III, Series, are not clearly definitive. Generally:

(1) The Ponderosa Pine Forest Series discriminates from other coniferous forests provided canopy (foliage cover) and slope steepness are not excessive. We have not yet defined excessive--we have a peripheral study under way now to determine the effects of slope steepness on the apparent spectral signature of this community class.

(2) Other coniferous forest Series classes--Spruce/Fir, Douglas-fir, and Lodgepole Pine--cannot be acceptably differentiated by visual interpretation of ERTS imagery. This is probably due to the near 100 percent crown closure of the vegetation representing these series at most locations within the 226C site.

(3) The Aspen Forest Series differentiates from all other Series components in the scene.

(4) Some grassland Series differentiate from all others provided the scene contrast is high. For example, dense meadows differentiate from all other kinds of grasslands. However, meadows with a shrub component such as species of willow or cinquefoil cannot be differentiated from those without the shrub component.

(5) Series within the dry mountain grasslands cannot be specifically differentiated. This is due probably to the confounding effects of amounts and kinds of live plant foliage, plant litter, and bare soil in the scene. The threshold level of amount of plant material required to maintain scene quality due to vegetation contribution to the spectral properties of the scene is not yet known.

3. On ERTS-1 supporting aircraft photography, we have not yet completed total interpretation testing using four interpreters. The following inferences can be made at this time, however.

a. Regarding forest classes, late season (September) 1:50,000 color infrared photographs provided better interpretive results for forest types than either early season (June) or smaller scale photos. The aspen class was correctly identified 100 percent of the time. Ponderosa pine, Douglas-fir, spruce/fir and lodgepole pine were correctly identified 81, 77, 65, and 44 percent correctly, respectively. Commission errors occurred mostly when tree canopies were nearly closed.

b. Regarding grassland classes, early season (June) 1:50,000 color infrared photographs provided the best discriminating evidence. The mountain bunchgrass class was identified correctly all the time. The shortgrass category was slightly confused with mountain bunchgrass but still 92 percent of the test cells were correctly identified. Wet herbaceous meadows and wet herbaceous shrub meadows could not be acceptably identified using any of the film/scale combinations.

4. The influence of amount of live herbaceous plant material in the scene in relation to the spectral response of that scene was determined by relating apparent image color to live plant foliage cover which was measured on the ground.

The following illustrates the relationship of a single color (ISCC-NBS notations) to a range of herbaceous plant cover:

Color		Range in % Cover
184.	v.p. Blue	5 only
182.	m. Blue	15-55
203.	p.p. Blue	25-60
261.	l. gy. p. Red	25-45
262.	gy. p. Red	25-55
253.	gy. p. Pink	30-40
227.	p. Purple	30-65
264.	l. Gray	35 only
244.	p.r. Purple	55 only
11.	v. Red	70-90
12.	s. Red	70-90

Inspection of these data shows that there is a threshold level in amount of live plant cover below which the spectral response due to vegetation is minimized. We believe this threshold occurs at about 30 percent live plant cover.

5. Five 15-mile-square areas within site 226C have been selected for the supervised and unsupervised computer classification. These areas will be used to generate thematic maps of vegetation and land-use classifications for cross reference with the computer classifications. Our computer classification has not progressed as rapidly as desired due to down-time of the computer to alter machine language.

6. Several internegatives have been made from combined image-enhanced 70 mm chips of selected ERTS-1 scenes of the 226C and alternate Kremmling test sites. This was done with the I^2S system at Berkeley using the process described in our Type I--Number 6 progress report. Prints have not yet been received.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. Complete interpretation of all supportive aircraft photos secured during two missions, MX 205 and MX 211.

2. As the bulk color composites of 1973 data of both site 226C and the Kremmling area are received, begin visual interpretation for relating apparent temporal change to image characteristics.

3. Reinitiate computerized classification of scene 1028-17135.

4. Complete if possible the design for our multistage sampling procedure.

5. Initiate contractual computer classification of two additional ERTS scenes provided the contract is issued.

SIGNIFICANT RESULTS:

The following significant results have been found:

Visual interpretation of ERTS-1 color composites of mountainous terrain does not always permit classification at the Series level in the plant community hierarchy. The Series represents a group of vegetation systems having a common dominant plant species, i.e., ponderosa pine forests, lodgepole pine forests, fescue grasslands, Danthonia grasslands. Provided scene contrast is high, such as wet meadows vs. dry grasslands, these levels can be interpreted successfully. Classification of coniferous forests depends on canopy (live crown) closure. Classification of upland grassland Series also depends on amount of live herbaceous plant cover in the scene. The threshold level below which the spectral contribution of live plant cover is minimized appears to be at approximately 30 percent, based on analysis to this time.

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGE: None

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: A total of 44 submitted.

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Black Hills Test Site (Forest Stress) 226A

Coinvestigator: F. P. Weber

GSFC Identification Number AG-014

Principal Investigator: Robert C. Heller

STATEMENT OF PROBLEMS:

1. A retrospective order for 7-track, 800 BPI bulk data tapes was submitted for the following five scenes:

1028-17121	Black Hills	August 20, 1972
1047-17175	Black Hills	September 8, 1972
1334-17124	Black Hills	June 22, 1973
1084-15440	Atlanta	October 15, 1972
1264-15445	Atlanta	April 13, 1973

Originally our plan was to duplicate the tapes as they arrived from GSFC so there would be tapes for our in-house processing and a set for the subcontractor for processing. Unfortunately, our Berkeley computer system is unable to duplicate the bulk data tapes without suffering large numbers of data dropouts. Consequently, we must request a second set for distribution to the subcontractor. Our proposal requires that the ERTS-1 tapes of the five selected scenes be available in Berkeley for the subcontractor prior to March 23, 1974.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Solicitations were sent to 28 prospective vendors (see below) requesting proposals for processing ERTS-1, MSS bulk data tapes. Seven MSS scenes were selected requesting the best data available for each of the three test sites. The solicitation is structured to encourage independent processing methodology for each test site so as to effect satisfactory results for each site despite the differing goals. The subcontractor will be selected by an evaluation panel on the merits of their proposals. According to the present schedule the selection panel meets March 15, 1974, and the contract award will be made no later than March 22. Terms of the solicitation require delivery of final products to the contracting officer's representative (Weber, COR) no later than May 31, 1974.

LIST OF POSSIBLE BIDDERS FOR PROCESSING ERTS MSS DATA

1. The Bendix Corp.
   Aerospace Systems Division
   3300 Plymouth Rd.
   Ann Arbor, MI 48107
   Attn: Dr. Robert H. Rogers

2. Environmental Research Institute of Michigan
   P. O. Box 618
   Ann Arbor, MI 48107
   Attn: Mr. Fred Thomson

3. Actron Industries, Inc.
   700 Royal Oaks Dr.
   Monrovia, CA 91016
   Attn: Mr. Melvin Lapides

4. TRW Systems Group
   Space Park Drive
   Houston, Texas 77058
   Attn: Mr. Don Kugle

5. Honeywell Systems and Research Div.
   2600 Ridgeway Parkway
   Minneapolis, MN 55413

6. Itek Corporation
   Optical Systems Division
   10 Maguire Road
   Lexington, MA 02173
   Attn: Mr. J. W. Sisk, Jr.

7. Stanford Research Institute
   333 Ravenswood Avenue
   Menlo Park, CA 94025
   Attn: Contract Relations

8. University of California
   Center for Remote Sensing Research
   129 Mulford Hall
   Berkeley, CA 94107
   Attn: Mr. Donald Lauer

9. Laboratory for Applications in Remote Sensing
Purdue University
Agricultural Experiment Station
Lafayette, IN 46207

10. Remote Sensing Institute
Hardin Hall
South Dakota State University
Brookings, SD 57006

11. HRB-Singer, Inc.
P. O. Box 60
State College, PA 16801
Attn: Mr. Paul Atolosky

12. The University of Kansas
Space Technology Laboratory
2291 Irving Hill Dr., Campus West
Lawrence, KS 66044
Attn: Mr. Robert M. Haralick

13. Dicomed Corporation
9700 Newton Avenue, South
Minneapolis, MN 55431
Attn: Mr. Don Uggla

14. Martin Marietta Corp.
P. O. Box 179
Denver, CO 80236

15. Lockheed Aircraft Corp.
2555 N. Hollywood Way
Burbank, CA 91505

16. Hughes Aircraft Co.
Corporate and International Offices
Culver City, CA 90230

17. Philco-Ford Corp.
Western Development Laboratory
3939 Fabian Way
Palo Alto, CA 94303

18. AC Electronics
2928 Nebraska Avenue
Santa Monica, CA 90404

19. Data Entry Management, Inc.
    1949 Stemmons Freeway (Suite 414)
    Dallas, TX 75207
    Attn: Victor C. Hajduk

20. Calspan Corporation
    4455 Genesee Street
    Buffalo, NY 14221

21. Analytical Systems Corp.
    11 Ray Avenue
    Burlington, MA 01803

22. Technology Service Corp.
    225 Santa Monica Boulevard
    Santa Monica, Calif. 90401

23. Data Dissemination Systems, Inc.
    11161 West Pico Boulevard
    Los Angeles, CA 90064

24. ESL Incorporated
    495 Java Drive
    Sunnyvale, CA 94086
    Attn: Michael W. Cobb
    Assistant Director

25. Technical Operations, Inc.
    Photo-Technology Div.
    Northwest Industrial Park
    Burlington, MA 01803

26. Digital Products Corp.
    4028 Northeast Sixth Avenue
    Fort Lauderdale, FL 33308

27. Cartwright Aerial Surveys, Inc.
    Executive Airport
    Sacramento, CA 95822

28. Martin Marietta Corp.
    Airport Imperial Bldg. #422
    999 N. Sepulveda Blvd.
    El Segundo, CA 90245
    Attn: Peter A. Abate
    Director of Western Region

2. Based on photo interpretation analysis of the 9 1/2-inch bulk color composites for August 20, 1972, and June 22, 1973, the following Black Hills ecoclasses were selected as training sets for all classified and mapping exercises:

ECOCLASS	LATITUDE	LONGITUDE
Wet Meadow		
Besant Park	N44°12'15"	103°39'00"W
So. Boxelder Draw	N44°11'14"	103°35'59"W
Englewood Draw	N44°17'18"	103°47'17"W
Dry Meadow		
Reynolds Prairie	N44°02'31"	103°48'12"W
Boulder Prairie	N44°23'52"	103°36'30"W
Dumont Pasture	N44°15'31"	103°47'40"W
Bare Soil and Rock		
Johnson Gulch	N44°21'32"	103°54'28"W
Bald Mtn Mine	N44°21'20"	103°50'07"W
Dumont Quarry	N44°14'27"	103°47'16"W
Water		
Pactula Reservoir	N44°22'17"	103°29'22"W
Iron Creek Lake	N44°22'17"	105°58'48"W
Dead Ponderosa Pine		
SA 2-1	N44°24'00"	103°50'36"W
SA 2-2	N44°21'00"	103°53'28"W
SA 2-3	N44°21'54"	103°52'41"W
Healthy Pine < 50% Crown Cover		
PP < 50-1	N44°17'48"	103°55'29"W
PP < 50-2	N44°48'47"	103°52'29"W
PP < 50-3	N44°15'32"	103°51'40"W
Healthy Pine > 50% Crown Cover		
PPG 50-1	N44°31'18"	103°49'53"W
PPG 50-2	N44°25'48"	103°52'12"W
PPG 50-3	N44°26'06"	103°52'13"W
Hardwoods		
HDWD-1	N44°11'24"	103°42'00"W
HDWD-2	N44°10'48"	103°41'17"W
HDWD-3	N44°11'53"	103°41'56"W

All of the above Black Hills ecoclasses were identified on the 9 1/2" bulk color composites created at GSFC and located on a Variscan viewer at 28 X magnification. Verification was made from 1:110,000 color infrared photograph and locations were pinpointed by reference to USGS 7 1/2-inch quadrangle maps.

3. During the last six months, the analysis has shown the suitability of various scales of 1972 Forest Service and NASA resource photography to assess forest insect damage in the Black Hills. In the previous reporting period an analytical model was developed using information from very large scale (1:5,500) NASA resource photography coupled with a minimum of ground checking. From these data the total number of infestation spots of bark beetle-killed pine was determined and classified into six size categories, ranging from 10 meters to 500 meters and greater in size. These data were determined for an area considered homogeneous in terms of the probability of insect damage. In addition, the proportion of the total number of damage spots in each category was determined as well as the mean number of trees in each category. Using the small scales (1:32,000, 1:100,000, 1:400,000) of Forest Service and NASA photography, a probability of detection was determined for each damage spot size category. Now that the photo interpretation on the 1973 resource photography is nearly complete, the predictive model will be tested against the photo interpretation.

One problem confronted during the analysis of the 1972 resource photography was in developing a reliable regression equation to relate the number of trees counted per infestation spot for each scale to the actual ground count. As reported earlier, attempts to fit a linear equation to an incomplete data base were unsuccessful. Various other non-linear models were tried again without success.

During the past six months attempts were made to improve the predictive model using the complete 1972 data base. A linear new equation of the type Y = beta 1 + beta 2X was found to fit the data. The beta coefficients were significant to the 0.05 confidence level for both the 1:32,000 and the 1:100,000 scales, while the beta coefficients for the 7:400,000 scale photography were statistically unacceptable (i.e., less than 0.15). The calculated coefficients for the two scales are:

Scale	Beta 1	Beta 2
1:32,000	3.822	40.113
1:100,000	4.913	39.910

The confidence limits about the mean values were as follows:

1:32,000 predicted value ± 6.117
1:100,000 predicted value ± 8.337

The photo interpretation of the September 1973 Forest Service and NASA resource photography of the Black Hills National Forest is nearly complete. Upon completion, the proportion, probability and linear regression coefficients developed using the 1972 photography will be tested against the 1973 interpretation results. Further, the same modeling techniques used the previous year will be applied and the coefficients compared.

4. Multispectral scanner imagery from Mission 213, September 14, 1972, has been analyzed with the following results to date: three of the best 13 unavailable channels were selected for color enhancement processing on the DAS at SSC, Houston. A technique was worked at for selecting optimum channels and using enhancement coefficients calculated from scene radiance data collected on the ground. The coefficients will permit us to map the Black Hills forest ecosystem and particularly to count and map bark beetle-killed ponderosa pine. Determinations were made of individual tree counts accuracies as a function of aircraft altitude from the first processed imagery. Intital PCM count correlations to actual tree counts were encouraging but suggested improvements to the enhancement coefficients would substantially improve the correlation. The second iteration is being processed at the present time.

5. Eucalyptus forests in the Berkeley-Oakland hills were killed by unusually cold weather in December 1972; the dying trees could be discriminated quite accurately on an enhanced ERTS image when they occurred in pure stands over 500 meters in size. A composite image (Figure 1) from two time periods was created on our optical combiner. MSS 7 with a blue filter, from the January 22, 1973, image (ID 1183-18175), was superimposed on MSS 5 with green filter and MSS 7 with red filter for the April 22, 1973, image (ID 1273-18183). The transparent overlay over Figure 1 shows identifying features around the Bay Area such as water bodies, bridges, and freeways identifiable on the image. Also, on this template the extent of the Eucalyptus killing is shown in dashed lines. The affected stand of timber were located on the template from underflight photography taken by the U. S. Forest Service on February 15, 1973, with Kodak Aerocolor Negative film (Type 2445) at a scale of 1:12,000. The Eucalyptus stands appear reddish brown on the enhanced ERTS image and can be separated from surrounding healthy vegetation.

An enhanced image such as the one shown in Figure 1 would be useful for damage assessment in remote areas when catastrophies of this kind occur. However, in an urban area, where millions of dollars for tree removal and fire prevention are involved, a more accurate sensor such as medium-scale color photography is needed. Several sets of the color photographs taken as ground truth underflight photography for ERTS were purchased by the cities of Oakland and Berkeley, the East Bay Regional Park District, and by insurance companies.

Figure 1.--A portion of composite image (enlarged to 1:500,000 scale) was generated from two dates of ERTS images ID 1183-18175 (January 22, 1973) and ID 1273-18183 (April 22, 1973) which show pure stands of Eucalyptus trees killed by prolonged cold temperatures in December 1972. The overlay outlines the larger stands (over 500 meters) which appear reddish brown on the enhanced print and which are distinct from other objects. An 8 X 10-inch internegative was made on an I^2S combiner at a scale of 1:1,000,000 and a 2X enlargement made of the affected area.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. The contract for processing the seven bulk MSS scenes will be awarded and training set data passed on to the vendor. The COR will work closely with the contractor during the period for producing the first iteration of classification and maps.

2. All of the DCP/DCS transmitted biophysical data will be analyzed with special emphasis on scene radiance data.

3. Interpretation of the 1973 resource photos will be completed and the photo interpretation data will be analyzed to provide tree counts by areas. The new data will be used to check the validity of the predective model for estimating numbers of infestation by size class.

4. Analysis of Mission 213 MSS data will be completed and final color composites will be compared to resource photo for verification of dead tree counts.